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ABSTRACT

At Triton College, student involvement with computers as a continued, multifaceted process is considered a primary objective of the physics and engineering department. To that end, the department implemented a low cost diverse program. The computer uses presented include labs, algorithms, testing, individual projects, drills, graphics, simulation, and rhetoric. The modes of computer use range from interaction to batch processing. Students enrolled in engineering are thus apprised of the scope and limitations of the computer after taking the sequence of courses in which computer utilization is incorporated. Primarily, the materials for the courses are developed to require the utilization of the computer in some form to guarantee the student's skill acquisition and progressive competency. The computer is programmed and sequenced to serve that purpose as well as to acquaint students with a wide variety of computer capabilities. (Author)

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COMPUTERS: NEW AVENUES FOR ENGINEERING STUDENTS AT THE COMMUNITY COLLEGE

by

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INTRODUCTION

At Triton College, a comprehensive community college, student involvement with computers as a continued, multifaceted process is considered a primary objective of the Physics and Engineering Department. To that end, the department implemented a low cost diverse program.

The computer uses presented incorporate labs, algorithms, testing, individual projects, drills, graphics, simulation and even rhetoric. The modes of computer use range from interaction to batch processing. Students enrolled in engineering are thus fully apprised of the scope and limitations of the computer after taking the sequence of courses in which computer utilization is incorporated. See Figure (1).

Primarily, materials for the courses listed are developed to require the utilization of the computer in some form, thus guaranteeing the student's skill acquisition and progressive competency. In addition, student use of the computer is programmed and sequenced so that these students become acquainted with a wide variety of computer capabilities.

INITIATION

Students entering an engineering curriculum in a community college rarely have a background in computers. While some of the feeder high schools offer computer programming courses, they are generally available only to "honor" students of whom Triton College sees very few. An ACT score distribution for engineering students entering in the fall of 1976 is shown in Figure (2).

The first objective in introducing students to computer utilization, therefore, is simply familiarization. Computer terminals are available in the physics/engineering lab/office complex with clear instructions for access

posted. Students are shown the computer during the first week of their Engineering Lecture/Rhetoric class and all are informed of data processing packages available.

CALCULATIONS

The students learn to use the computer for tedious calculation work in lab, certain demonstrations and data gathering assignments. For physics, programs exist to do linear regression curve fitting for lab data. Calculations such as mean and standard deviation can be done either by means of computer programs or by programmable calculators. Students in engineering lecture gather data from questionnaires. A computer package exists to collate responses and report them with mean and standard deviation as well as distribution curves. One of the most important things a student learns is that the computer is not always the appropriate place to take calculations which could be handled more rapidly with calculators.

DRILL & PRACTICE

Several computer assisted instruction modules provide another important aspect of instruction, namely drill and practice. In physics, there are many relatively simple principles for which intellectual development occurs maximally by repeated application to varying problems. Modules using this technique include center of mass, work and energy, thermodynamics, RC circuits, DC circuits with meters, and magnetic fields due to parallel wires.

Students in Engineering Lecture/Rhetoric (a team-taught combination of introduction to engineering and freshman English) presently are given as part of the course a vocabulary list which must be mastered. A computer file for

comprehensive testing has been developed. Two simultaneous objectives will be met:

1. The academic objective. Students will respond on a multiple choice basis and will receive immediate error analysis response. Records of wrong responses will be kept, with the student being responsible to retake words missed. Furthermore, faculty will be able to retrieve class data to determine most frequently missed vocabulary.

2. The computer familiarization objective. Access to the vocabulary unit is simple, consisting of user and program identification. Interaction with the program is also simple, requiring only typing of the number corresponding to chosen response, waiting for evaluation (right or wrong) and pushing the return key.

In statics/dynamics drill and practice programs are used for remedial purposes. Students failing to demonstrate comprehension of certain principles must practice them on the computer before retesting is permitted. For instance, programs exist in statics for three dimensional vector calculations, location of centroids and determination of moments of inertia.

The CAPS project, a significant part of drill and practice at Triton College is of major scope and will be discussed in the next section.

HOMEWORK

A computer managed system at Triton College provides individualized homework problems. The project is called Computer Administered Problem Sets (CAPS). The objectives are to modularize the assignments to provide self-pacing, to assure mastery, and to minimize copying and procrastination. Many experiments have shown that the best way to improve problem solving abilities is by using small steps at a pace appropriate to each student and to provide immediate feedback. Such a modular system organizes all the instruction and insures that students cannot proceed without demonstrating competencies in needed subskills. The computer is needed to manage the

system and to interact with the students whenever the students need the feedback.

The CAPS project consists of two components:

1. Computer written and printed homework.

   (a) 20 problems are entered into a program (PROBS) which computes one correct answer and four distractor answers for each of 10 variations of each problem.

   (b) They are printed 5 problems to a page with correct answer printed in a random manner in one of five choices (a) through (e).

   (c) Options include (1) up to 3 answers per choice (where more than one answer is needed); (2) non-numerical answers can be given either by hand-typing or by using a coding scheme.

   (d) Output includes 20 versions of each page in such a way that each of the 10 variations of each problem occur twice but in such a way that no two versions are identical. Two copies of each version are printed and one copy with answers for our files.

2. Computer managed and graded homework.

   (a) Students work their assigned set each week (20 problems). They enter their answers (a to e) into a program (HOMWRK). The program grades them and tells them which ones they missed. Success is 80% or 16 problems out of 20.

	TRIAL	GRADE
80%	1	A
80%	2	B
80%	3	C
80%	4	D
80%	5	F

   (b) Students may not proceed to the next set until they have achieved 80% of the previous set.

   (c) To prevent procrastination, 3 sets must be completed prior to each of 5 tests. If all three sets are not completed by the test, the grades for all three sets revert to F.

TESTING

The computer administered testing system (CATS) at Triton has been implemented in graphics and statics/dynamics and will be implemented in physics.

Statics/dynamics and graphics are presently taught in a modularized, self-paced manner, with minimum standards of three modules per month in mechanics and one test per month in graphics required to assure completion of the course in the time traditionally allocated. Modules consist of objectives, lectures, solved problems, and assigned problems. Extensive use is made of audio-visual materials (slide-tape presentations, sound page, videotapes), lectures are presented when appropriate, and a tutoring service is relied upon for developmental purposes.

When a module is completed, testing is done by means of a computer. The computer both generates tests and manages test results. The student interacts with the computer as follows:

1. The computer is accessed with identification number and module (test) number.
2. The computer randomly chooses one problem of each type for that test, and prints the problem for the student.
3. The student takes the test and receives a hand graded result back.
4. If a student fails an exam, evidence must be shown that comprehension of the subject exists before retesting may be initiated.
5. For a retest, problems are again randomly chosen from the problem file, but problems previously assigned to that student are omitted from the file.

The instructor interacts as follows:

1. Answers to test taken by a student may be accessed at any time.
2. The number of times the student has taken all tests is recorded.
3. The faculty has contact on retesting. If a student has not shown any further work on a particular module, he (she) will not be able to access the computer to retake the test.

The testing method allows students to take tests at their convenience (the testing center is open 80 hours/week). Cheating is minimized by use of extensive files where each problem is different (not just numbers).

ALGORITHMIZATION

There are many principles in physics which are considered formal operational in the sense of Piaget[1] model of intellectual development. Renner[2] and others have shown that a significant number of college level students operate intellectually at a concrete level. It has been shown that such students must observe physical phenomena directly by manipulating equipment themselves in order to progress to the formal operations stage in the discipline. Thus, a student can be taught to deal formally with the equation F = ma by requiring that he "discover" the relation by means of a laboratory exercise. However, there are many principles of physics which are primarily formal operational, i.e., there are few, if any, physical phenomena for students to directly observe to "discover" the principle. Algorithms which are at a lower cognitive level than principles provide an alternative approach to making formal operations "concrete." The algorithm provides a "hands-on" prescription for applying the principle.

Several computer aided modules have been developed in which algorithms are taught to students. Among these are units on kinematics, vectors, Gauss' Law and Ampere's Law. The idea is to present the students with a series of rules for applying the principle and then to lead them through the various concepts with several examples, each time providing progressively fewer prompts. Then the student is tested on the use of the algorithm on a few examples with no prompts given. In the case of Gauss' Law and Ampere's Law, the instruction

is provided in a totally self-paced manner by computer. The basic component of such a "programmed" system of instruction is that the student must master all subskills before proceeding to higher level skills.

SIMULATION

Simulation experiments are currently bieng successfully run by students in physics, statics/dynamics, and strength of materials. The main advantage in the simulations is the fact that they are "ideal" experiments. Unlike true experiments which are plaged by a variety of systematic errors, simulations demonstrate the particular physics principle in an errorless fashion. Generally, students vary several of the independent parameters, one at a time, and see how the results are affected. Conclusions about cause and effect follow readily and students are able to deduce the correct principle. In addition, the time required for all possible variations of parameters is much less than with a true experiment.

In physics, programs run by students include projectile motion, energy conservation, collisions, electric and magnetic field plotting, DC circuits, RLC oscillations, Maxwell-Boltzmann statistics, wave interference, geometrical optics, diffraction grating, relativity, photoelectric effect, and Compton scattering. The subject of the simulation in Fig. 3 is projectile motion. For this case, the student can input the initial speed and the angle. By selecting thirty and sixty degrees, the student readily sees that the range is the same for complements of an angle as for the angle. Also, by trying other angles around forty-five degrees, the student readily sees that the range is a maximum at forty-five degrees.

Statics and dynamics simulation programs exist in which variation of parameters clearly demonstrates phenomena. Examples of this are:

1. piston acceleration for various crank angles.
2. location of principal moments of inertia by rotation of axis.
3. single degree of freedom response for variation of m, c, and k.
4. forced vibrations of clamped single degree of freedom problems.

In strength of materials, students have access to a "card" program to calculate shear, moment and deflection values for a straight beam under any loading and for any determinate support system. Students are for the first time exposed to non-interactive batch processing.

PROJECTS

Students in graphics and statics/dynamics may elect to do a computer project to meet the requirements of the courses. For graphics they may:

1. Digitize drawings from their sketches and then manipulate them with the computer.
2. Compare drawn output against the computer output.
3. Solve graphics problems on the computer.

When students enroll in statics/dynamics, a majority have already taken computer programming (Fortran IV, calculus prerequisite). Students may choose computer programs to meet the elective portion of the statics/dynamics course. Students have written programs to find centroids and moments of inertia for general geometries and for the determination of forces in trusses and the generation of equivalent systems. The student written programs, when appropriate and educationally valid, are altered where needed and placed at the disposal of all students.

VALIDATION

Extensive testing of student response has been done in physics. All the modules prepared to date have proven to be successful in increasing student achievement. A comparison was made of scores on tests of certain topics covered by CAI. Students in the experimental group had the traditional lecture and CAI as a supplement. Students in the control group had straight lecture. Typical results are shown for five units in Fig. 4.

For the two programs on Gauss' Law and Ampere's Law, a test experiment was performed in which a randomly chosen student body was selected for experimental and control groups. The control group received lecture, textbook and homework problems on the two topics. The experimental group received the CAI material in addition to the lecture,textbook and homework problems. The control group was provided with a "placebo" CAI problem to alleviate "Hawthorne effect"[3] problems. Figure 5 shows the results of the comparison of experimental groups to control groups for the Gauss Law unit. Similar results were obtained for Ampere's Law unit.

The data in Figure 5 indicates that the algorithmic presentation was superior to the "standard" lecture-recitation presentation. Students who had the special instruction performed significantly better (using the t-test) on the post-tests than the control groups.

Validation of the use of the computer in graphics and mechanics is based on a 140 item questionnaire developed by Triton College and correlation of achievement before and after introduction of the new material. Student response is positive with the exception of major complaints about a consistently heavy work load. Students may no longer flunk a test and proceed, and they don't like it. The retention rate before and after introduction of the new

material is approximately the same. However, with the new material, students are automatically dropped if they do not meet the minimum pace. Student achievement has improved markedly, as evidenced by higher grades and a lower percentage of students receiving F's.

CONCLUSIONS

The Triton College experiment introducing students to the computer has shown that a community college can, effectively and at low cost, implement a multifaceted program, without reliance on sophisticated programming techniques or outside expertise. The total investment in hardware is less than $9000. All programs discussed in the paper have been developed by Triton faculty and student aids. Faculty programming has been subsidized by internal research grants and students have been paid from work study grants. Some of the material presented in this paper has been developed with the aid of a grant from the National Science Foundation (CAUSE).

While student achievement of certain objectives in physics has been proven to be enhanced when the student is exposed to the computer assisted instruction materials, probably more important is the student enthusiasm that has surfaced with the computer exposure which has led to many voluntary computer projects.

The faculty of the Physics and Engineering departments fully believe that the computer experiment has increased academic competence of the student and has also thoroughly familiarized students with a universal tool of engineering.

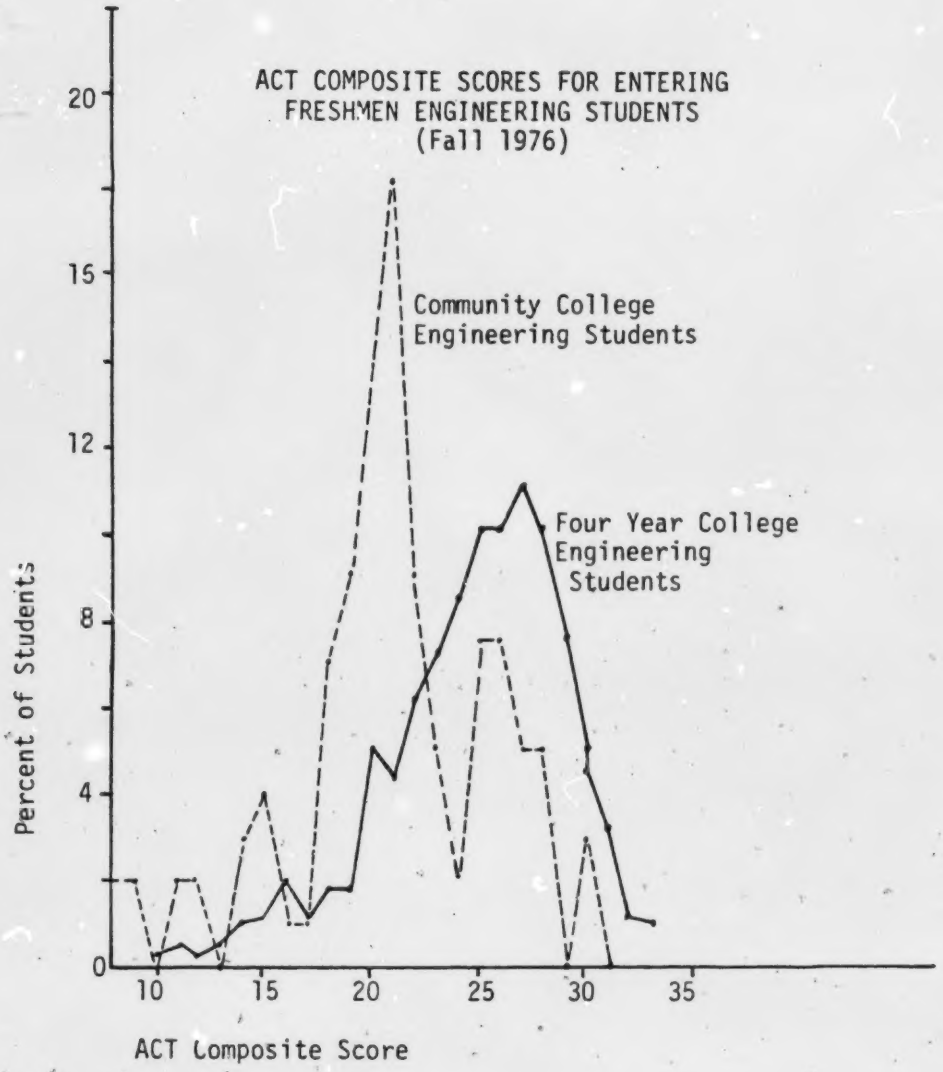
BIBLIOGRAPHY

1. John L. Phillips, The Origins of Intellect, Piaget's Theory, (New York, 1975).

2. John W. Renner, "Significant Physics Content and Intellectual Development - Cognitive Development as a Result of Interacting with Physics Content," American Journal of Physics, Vol. 44:218, March 1976.

3. Donald T. Campbell and Julian C. Stanley, Experimental and Quasi-Experimental Designs for Research (Chicago, 1966).

Figure (2)


ACT COMPOSITE SCORES FOR ENTERING
FRESHMEN ENGINEERING STUDENTS
(Fall 1976)
Community College
Engineering Students
Four Year College
Engineering
Students
Percent of Students
0
4
8
12
15
20
10
15
20
25
30
35
ACT Composite Score

First Semester	Engineering Lecture/Rhetoric Engineering Graphics
Second Semester	Physics (Mechanics)
Third Semester	Physics (Electricity and Magnetism) Computer Programming (Fortran IV) Statics
Fourth Semester	Physics (Waves and Modern Physics) Dynamics Strength of Materials

Figure (1)

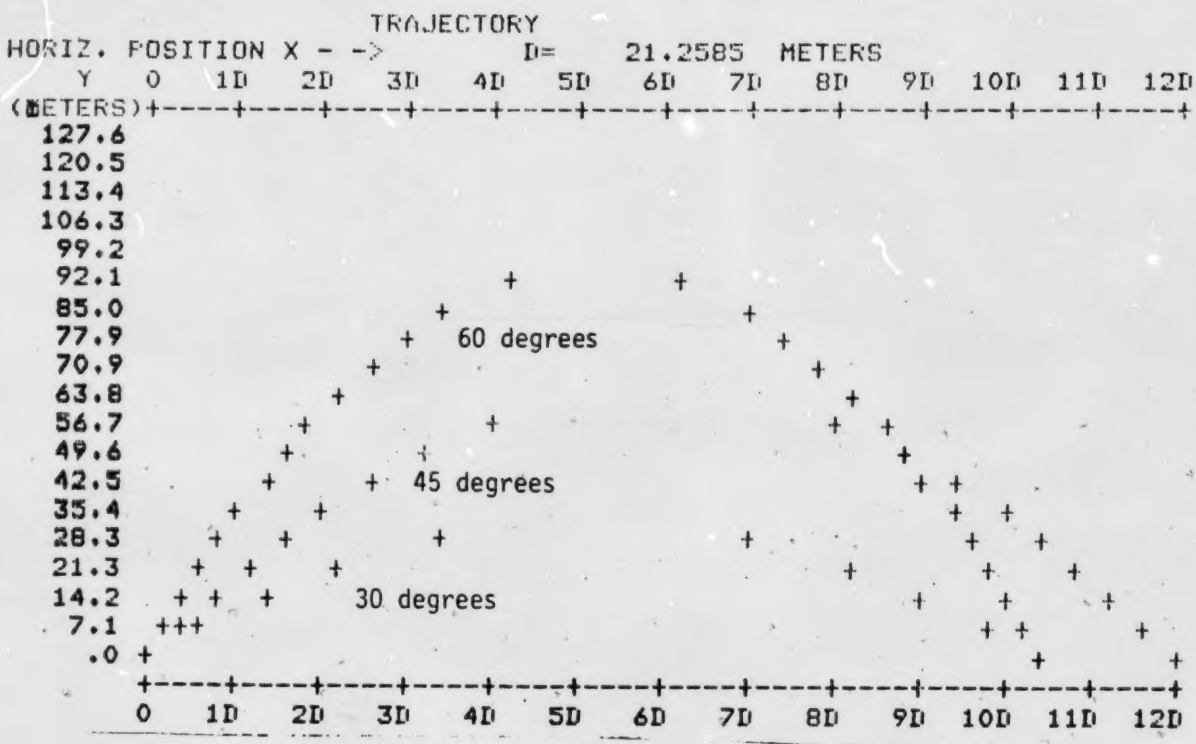

TRAJECTORY
HORIZ. POSITION X - ->
D= 21.2585 METERS
Y (METERS)
0 1D 2D 3D 4D 5D 6D 7D 8D 9D 10D 11D 12D
127.6
120.5
113.4
106.3
99.2
92.1
85.0
77.9
70.9
63.8
56.7
49.6
42.5
35.4
28.3
21.3
14.2
7.1
.0
60 degrees
45 degrees
30 degrees

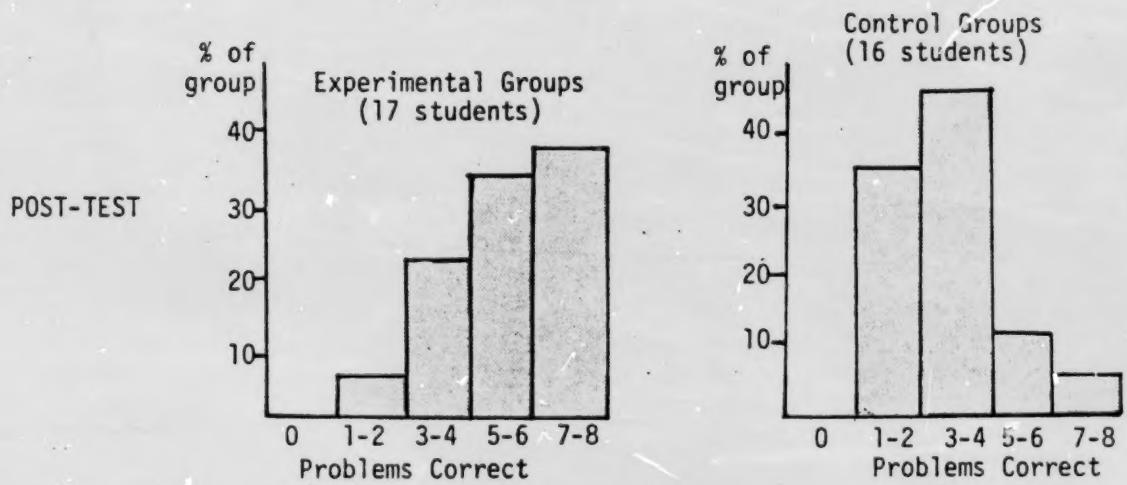
Figure (3)

	Control	Experimental
DC Circuits	51%	87%
RLC Circuits	48%	80%
Waves	70%	84%
Interference and Diffraction	62%	85%
Compton Scattering	32%	43%

Percentages are the percentages of the class who were successful with the particular problem pertaining to the topic.

Figure (4)

GAUSS' LAW



T TESTS FOR SIGNIFICANT DIFFERENCES

Pretest P1: $t = 0.17$ not significant

Post-test T1: $t = 3.69$ significant ($p < .01$)

Figure (5)